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THE CONTROL OF APPLE BLOTCH.

By D. E. Lewis

IMPERIAL BUREAU OF MYCOLOGY 13 JUL. 1921

FIG. 21. Blotch upon Missouri Pippins.

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Summary.

1. The apple blotch, a disease that frequently causes over 90 per cent of injury to susceptible varieties, has been successfully controlled on the fruit, the first season sprayed, by the application of Bordeaux mixture.

2. By the continued use of Bordeaux during successive seasons the disease can be almost completely eradicated from the orchard in from four to six years. The 3-4-50 Bordeaux can be safely used, if made and applied only as recommended.

3. It is especially necessary in the control of this disease that the spraying be done with absolute thoroughness, and at the time indicated in the schedule.

4. Lime-sulphur solution is less effective than Bordeaux mixture, for blotch control, but should always be used during wet weather, on account of the tendency of Bordeaux to cause injury at such a time.

5. The work of eradicating the blotch fungus can be hastened, the chance for injury lessened, and the commercial value of the fruit increased, by carefully cutting back the affected trees.

6. This cutting-back process strengthens the framework of the tree, and throws it into vigorous growth. Advantage may be taken of this growth to increase and lower the bearing surface of the tree.

The Control of Apple Blotch.

By D. E. LEWIS, *Assistant Horticulturist.*

Introduction.

DURING the past ten years a disease has invaded Kansas orchards which already is causing greater annual loss to the apple industry than any other disease which attacks the fruit. Originating in the southeastern section of the United States, it has rapidly spread north and west, until at present it is found throughout the entire eastern half of the apple belt. The greatest damage in the Central West has been reported from Arkansas, Missouri, Oklahoma, Illinois, and Kansas, but other states are reporting more injury each year, and from present indications it is only a matter of time until the entire West as well as the East will be invaded.

This disease, the apple blotch, is peculiar in that it attacks some varieties with extreme severity, while others are almost immune. The planting of the Missouri Pippin, an apple possessing many desirable qualities, has been almost entirely discontinued in this state during recent years on account of its susceptibility to the blotch injury. The Ben Davis also suffers severely, and as large acreages of this variety are found in the Middle West, the per cent of injury is thus materially increased in this section.

The greatest loss has occurred among unsprayed susceptible varieties, but frequently sprayed orchards suffer severe injury also, since the spraying is not ordinarily done at a time that will successfully check the disease. Orchards composed entirely of unsusceptible varieties usually escape injury, but if the most susceptible varieties are interplanted with the resistant, both are liable to become affected, though a remarkable degree of difference always remains in the severity of the injury. On account of this variable injury to standard varieties, it is difficult to accurately estimate the loss incurred, but during the past three or four years many orchards have lost from one-third to one-half of the entire crop, and not infre-

quently a total loss is reported among the most susceptible unsprayed varieties.

The first injuries noticed in an orchard are not usually severe enough to cause the grower much uneasiness, but as the cankers multiply upon the trees the per cent of the crop destroyed rapidly increases, until finally this fungus is more dreaded than all other fruit diseases combined.

In orchards thoroughly sprayed with Bordeaux the disease is much less destructive, and by an arrangement of the schedule of application, so that the spraying is done at the time of greatest infection, this mixture will control 90 per cent or more of the injury.

The attention of the Station has frequently been called to this disease during the past few years, but not until 1910 was it possible to give the disease the attention its importance seemed to demand. During that year and the two following, experiments were carried on to determine a safe and effective method of control. The results obtained during 1910 were included in the Kansas Experiment Station Bulletin No. 174, but will be reviewed in this discussion, together with the work of the past two seasons.

Cause of the Disease.

The blotch is caused by the fungus *Phyllosticta solitaria* (E. & E.), which lives parasitically upon the fruit, twigs and leaves of the apple. This fungus was first described upon the leaves of the wild crab apple by Ellis & Everhart[1] in 1895. In 1902 Clinton[2] described it upon the fruit of the apple, and decided it was caused by an unknown species of *Phyllosticta.* Scott & Quaintance[3] published a description of the injury and recommendations for its control in 1907. In 1909 Scott & Rorer[4] published the results of a series of experiments conducted in Arkansas. They determined by cross-inoculations that the disease upon the fruit and that upon the twigs and leaves were both caused by this same fungus. About the same time Sheldon[5] reported similar results from a series of cross-

1. Ellis & Everhart. Proceedings of Academy of Natural Sciences, Philadelphia, 1895.
2. Clinton. Ill. Agr. Exp. Sta., Bul. No. 69.
3. Scott & Quaintance. U. S. Dept. Agr., Farmers' Bul. No. 283.
4. Scott & Rorer. Bureau of Plant Industry, Bul. No. 144.
5. Sheldon. Science N. S. 26, No. 658; Aug. 9, 1907.

inoculations. Other reports, dealing mostly with the increasing importance of the disease and recommendations for its control, have been published, but until the experiments herein contained little progress was made in the control of the disease in Kansas.

What is a Fungus?

It is well to remember, in considering this disease, that a fungus is a plant, and is spread by means of spores in much the same way that the higher forms of plant life are multiplied and spread by seeds. There is also a network of vegetative threads, or mycelium, which grows within or upon the host and derives nourishment from the cells of the host plant, much as the higher plant takes its food from the soil. The effect of this robbery is made evident by numerous forms of injury, such as fruit and leaf spots or cankered areas upon the host. The appearance of this injury varies with the fungus causing the disease, and is one of the common means for the identification of the fungus. As the mycelium continues in growth it forms various kinds of fruiting bodies, which bear spores, and these spores are capable of reinfecting the host plant or other plants, and thus spreading the disease.

Some of the fungi produce resting spores during the latter part of the season, which lie dormant over winter and germinate the following spring, thus carrying the disease over the winter. In others this resting spore stage seems to be entirely absent, and the disease is carried over from season to season by the mycelium, which lives in some part of the wood, leaves or fruit of the host plant. In this latter case the mycelium resumes activity with the growth of the host, and soon produces spores, which again infect the various parts of the plant.

Life Cycle of the Blotch Fungus.

The fungus causing the apple blotch belongs to the last described group, or at least no resting spores have been found, though a careful search is being made by many investigators for this perfect stage. Cankers are formed upon the young wood, in which the mycelium passes the winter, becoming active again about the time the tree resumes growth the following spring. The cankered area spreads quite rapidly for a few weeks during this early part of the season, and about the time the petals fall, spore cases begin to appear on the advancing margin. The majority of these spore cases burst from four to six weeks after the petals have fallen, and the mature spores are disseminated over the orchard, mainly by water and wind, but some undoubtedly by insects and other common agencies. Although the greatest amount of infection takes place during the fourth and fifth weeks after the petals fall, a few spore cases open earlier than this and some are maturing and rupturing later. On account of this condition, the entire infection period may be said to continue from about three weeks after the falling of the petals, through the remainder of the growing season, or at least until the latter part of August. From midsummer on, during the remainder of the season, spore cases bearing spores are formed in constantly decreasing numbers, while the number formed which do not bear spores increases. On this account it is difficult to find spore cases containing spores during the fall or winter.

Appearance of the Mycelium. When a spore of the blotch fungus falls upon the fruit, leaf or current wood growth of the apple, during favorable weather conditions, it germinates and sends a germ tube into the tissue. This tube branches and forms a network of irregular, septate, vegetable threads, called mycelium. At first these threads are hyaline, but become brown, and finally a dark olivaceous or black. It is largely this dark mass of mycelium that gives the blotch injury its dark color on the fruit and twig. The mycelium spreads slowly in the layers of cells just below the epidermis or bark, but does not penetrate deeply at any time. Frequently the cells killed collapse, and the effect is a sunken spot upon the surface of the injury.

The Spore Cases or Pycnidia. A short time after the injury becomes visible upon the part attacked, small, dark eruptions are noticed scattered or grouped over the surface. These are called pycnidia, and are spore cases containing a mass of spores, surrounded by a very dark, thick mass of mycelium. The pycnidium shown in figure 1 was secured from a blotch spot upon an apple. Only a few spores are visible, the remainder having escaped through the opening at the surface of

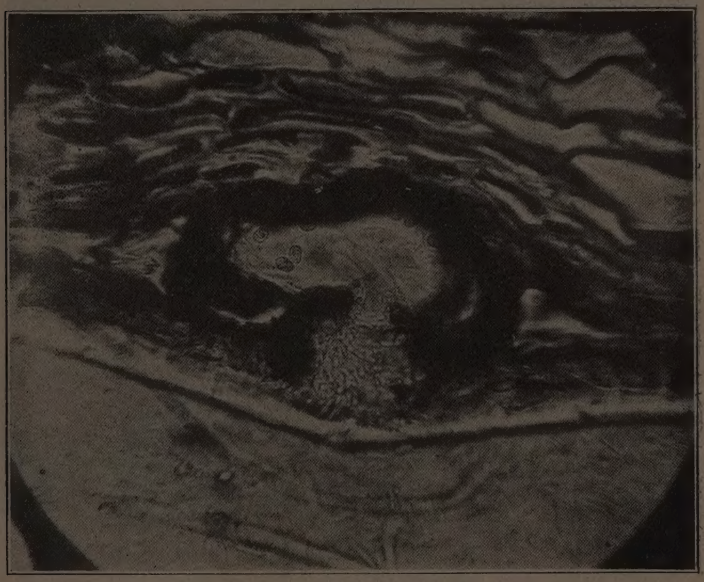


FIG. 1. Cross section of a pycnidium from a fruit blotch. Notice the dark mass of mycelium bounding the pycnidium. A few spores are visible, the remainder having been dispersed.

the fruit. New pycnidia are constantly being formed upon the advancing growth of the mycelium during the fore part of the season. The spores mature and escape, leaving the empty pycnidium still plainly visible, but no longer dangerous. Those formed late in the season usually contain no spores, though a few have been found which are fertile at this time.

The Spores. Great quantities of hyaline one-celled spores are borne in each pycnidium. They measure 8-11 x 5.5-6.5 μ in size, and the walls, while usually regular, are occasionally distinctly compressed. Frequently the spore is largest at one

end. Some are almost globular. They are borne on short, thick sporophores arising from the vegetative strands lining the pycnidium, and have an indistinct, mottled appearance.

In the laboratory the spores germinate in from twelve to eighteen hours, sending out one or two germ tubes, which soon form a network of mycelium. (Fig. 2.) No spores were pro-

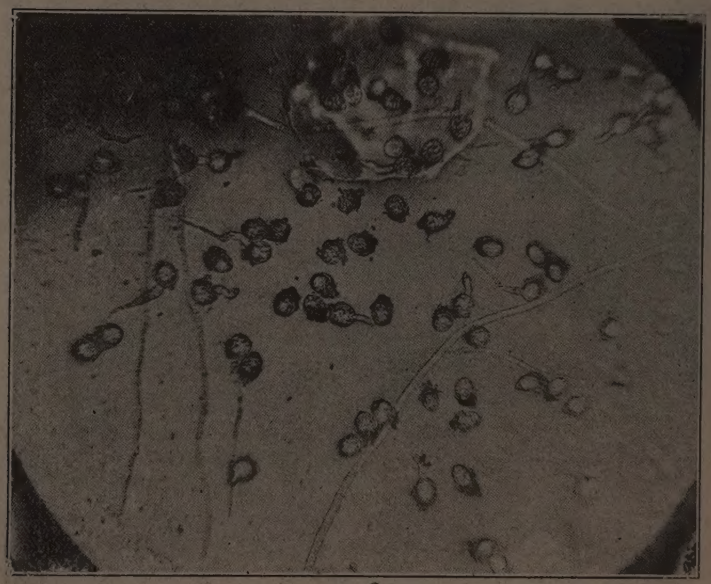


FIG. 2. Germinating spores of the blotch fungus. Spores germinate in the laboratory in from 12 to 18 hours. The long strands of mycelium do not belong to this fungus.

duced in prune or potato agar or on potato cylinders, but apple-wood cultures produced spores abundantly. An attempt was made to infect ripe apples in the laboratory, but each case failed to develop a characteristic blotch spot. The germ tube seems unable to penetrate the hard portion of the plant, but gains entrance through the fruit, leaves and current year's wood growth. The spore is killed if brought in contact with a fungicide before the germ tube enters the plant tissue, but after the entrance is effected no amount of spray will check the growth of the mycelium, unless it does so by killing the tissue of the plant itself. It is therefore of the utmost importance, in the control of this disease, to keep all susceptible

parts well covered with an effective fungicide during the period of greatest spore dissemination.

Sources of Infection. The two sources of infection are, as has been noted, first, the cankers, and second, the diseased fruit. As the cankers enable the fungus to live from season to season, a destruction of all cankers in the orchard would, of course, check the disease. This process is not, however, the most practical, as by removing all useless infected wood, such as water sprouts and greatly weakened twigs, and keeping the new wood growth entirely covered with a fungus spray during the summer, the disease is prevented from forming new cankers. The old cankers do not usually live more than three or four years, so that such a process would almost entirely eliminate the disease in four or five years.

Description of the Injury.

Upon the Leaf.

The effect upon the leaf is first noticed about six to eight weeks after the petals have fallen. Small irregular spots, light yellowish green in color, occur upon the upper side of the leaf blade, and upon the veins, midrib and stem of the leaf. These spots are easily overlooked during the fore part of the season, as they are only about one thirty-second to one-sixteenth of an inch in diameter, and but a little lighter than the leaf in color. A small, black pycnidium-like pimple is found upon each spot, and as the spots often coalesce or overlap it is not uncommon to find two or three of these eruptions apparently upon the same spot. By girdling the leaf stem the leaves are frequently killed. Often a canker-like spot is produced upon the leaf stem and midrib, resembling closely the canker upon the twigs. As the season advances the spots gradually become lighter in color, until by the time the fruit is ripening they are often almost white and quite conspicuous. (Fig. 3.) They vary in number from only a few to several hundred upon a single leaf, and in the most severe cases are so numerous as to seriously impair the normal function of the leaves, thus weakening the tree.

The black pustules upon the leaf spots would suggest that spores were formed and disseminated from them, but these pus-

tules seem to be entirely sterile. Spores have been found upon the base of the leaf stem, but not upon the leaf blade. Leaves carried over winter fail to produce spores the following spring; this is true also of those found under the tree in the spring. The injury to the tree from the fungus upon the leaf is limited, apparently, to possible infection of the twig from the petiole and to the checking of normal leaf action, and consequently to a reduction of available plant food. In severe

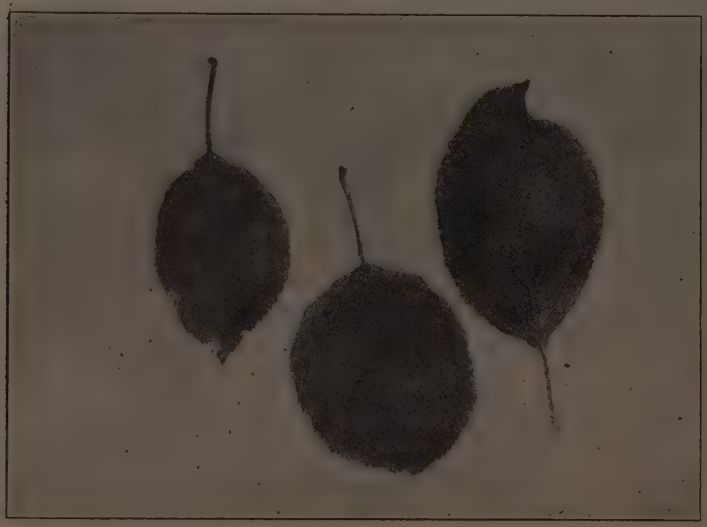


FIG. 3. Apple blotch leaf spots as they appear in the fall. Notice the canker-like spots upon the midrib and petiole.

cases, no doubt, this aids greatly in the destruction of the tree. Occasionally badly affected trees are almost entirely defoliated during the latter part of the summer.

UPON THE TWIGS AND BRANCHES.

The growth of the fungus upon the woody part of the plant is confined mainly to the twigs and watersprouts, being found later as a rough, much-cracked scar upon the larger limbs. (Fig. 5.)

The fungus gains entrance through the current year's growth, and appears in the fall as a dark olivaceous-colored spot, varying in size according to the time of the infection

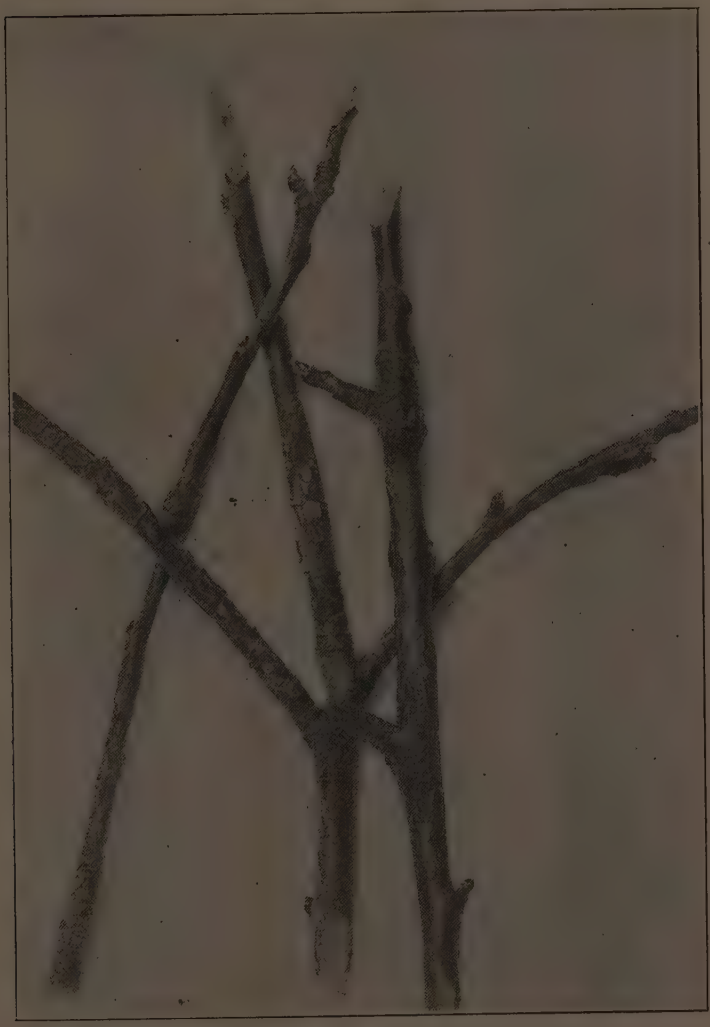


FIG. 4. Twig cankers in which the fungus has lived over two or three winters.

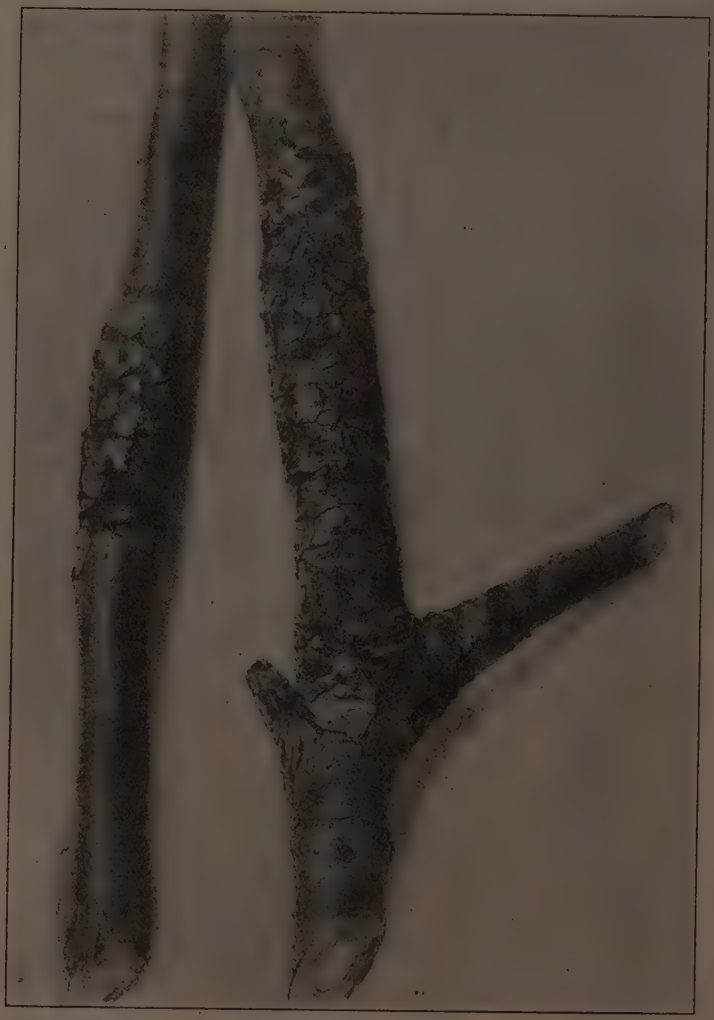


FIG. 5. Old cankers as they appear upon the larger twigs and limbs. No spores are disseminated from such cankers.

during the summer. Upon rapidly growing twigs and water-sprouts these spots are large, often measuring one-half inch or more in length and about one-half as wide. Such a canker frequently bears spore cases near the center during the first season. Not only are these cankers upon the rapidly growing wood larger, but they are also much more numerous and conspicuous. The center of the diseased area frequently becomes brown or tan colored, while the margin retains its dark green color.

Upon the firmer, slower-growing twigs the diseased spots are much smaller, and usually do not show a tan center the first season. Pycnidia are frequently found upon them, but if produced during the latter part of the season they are usually sterile. On account of the heavy pubescence upon the young wood, these cankers are not easily seen during the first season, but by rubbing this pubescent growth off, the dark brown, almost black canker is plainly visible.

Shortly after tree growth starts the following spring the fungus also becomes active, and a well-defined, regular discoloration is maintained between the advancing margin and the healthy bark. The old portion of the canker changes to a tan or bronze color, while the new portion is dark olivaceous. The fungus confines itself to the soft wood tissue, only a slight discoloration being noticed in the outer portion of the heart wood. The growth is again much more rapid in the water-sprouts and rapidly growing twigs, and frequently the tan portion is deepened in color, becoming an orange-tan, while the new growth is very dark green.

Pycnidia are formed upon the new growth of the fungus, which at this time are very rich in spores. As a very small amount of moisture is required for the germination of the spores, dry weather does not check the blotch to the same degree that it does other orchard fungi, hence the regular recurrence of this disease each season, whether wet or dry.

Spore-bearing pycnidia continue to be formed during the first half of the summer, but from about the first of July the number of pycnidia bearing spores steadily decreases, until by the first of September spore dissemination from this source has almost or entirely ceased.

So far as the writer has been able to determine, spores are

never borne a second time upon the portion of the canker which has fruited, but always upon the younger, advancing margin.

During the second season the canker produces a very great number of spores—more, usually, than are produced during any following season. Often during the latter part of this year, but more frequently the third year, cracks and rifts appear, separating the canker from the healthy portion of the twig. A canker thus isolated dies, and the wound usually heals, remaining only as a roughened scar, which often completely encircles the twig, but may be noticeable on one side only. In other cases the canker may girdle and kill the twig upon which it is growing. Large numbers of these dead twigs produce the ragged appearance common to trees badly affected with blotch. Sometimes the canker continues in its normal growth for three or four seasons, or perhaps more, but usually by the end of the fourth season the twig has been killed by girdling, or the canker has been cut off from its food supply and becomes a slightly raised, roughened scar. Such a scar, as the limb enlarges, may become two or three or more inches in width, but none has been found producing spores in this condition. A twig canker three or four years old which is still growing and giving off spores often shows three or more distinct colors, the center or oldest portion being a grey or greyish tan, the next year's growth, which immediately surrounds this, a tan or bronze, while the outside portion is very dark green. The old spore cases are still visible on the grey and tan portions, but only those formed upon the young growth are active.

Occasionally the cankers are crowded so closely upon the twigs as to lose their characteristic markings, showing only as grey or tan spots much fissured and furrowed by cracks. Limbs which show this condition should be removed a foot or more below the last live canker, as the disease renders them useless to the tree, and the chance for infecting other branches and fruit is increased by their presence.

Growth upon the Fruit Spurs.

One phase of the injury to which little thought seems to have been given is the killing of the fruit spurs. Scott & Rorer[6] have suggested the possibility of injury through the

6. Bul. No. 144, Bureau of Plant. Ind.

killing of the fruit buds in late summer by this and the black-rot fungus, but although this condition has been found in the orchards of this state, the killing of the fruit spurs seems to be even more serious. There is no part of a badly cankered tree more seriously injured than the fruit spurs. The effect of this injury is, of course, to reduce, or in the worst cases to almost entirely prevent, a setting of fruit. The fungus sometimes enters from the leaf stem, and at other times through the new growth just below the bud.

It seems likely, also, that entrance may be gained by spores which have lodged in the roughened scales along the fruit spur. The appearance of many of the cankers indicate that this is the case. However, this point has not been fully established.

During the fall of 1911 several Missouri Pippin trees which for several years have been badly affected with blotch were carefully examined, and it was estimated that fully 50 per cent of the fruit spurs were dead. Several examinations of these trees during the past season show an average setting of less than one-fourth of a crop, and in several cases less than one-tenth of a crop was set.

Although this orchard has been neglected and is in very bad condition, other varieties, such as Winesap and Grimes Golden, the twigs and fruit spurs of which are not much affected by blotch, set a heavy crop.

Another examination was made of these trees during November, 1912, and a careful count made of the live and dead fruit spurs upon twenty-five branches located in various parts of the trees. Five typical trees, chosen at intervals covering the entire block, were selected for the count, and five branches were examined in each tree. These branches averaged from four to five feet in length, and all side branches borne by them were included in the count. Complete data are given in the following table in order to show the location of the greatest number of dead fruit spurs. In the second column, labeled "Position of limb," the letter indicates the situation of the limb upon the tree, as north, center, top, etc., and the figure represents the height of the limb from the ground.

TABLE I.

Tree.	Position. of limb.	Total number. of spurs.	Dead spurs.	Live spurs.
A	S—6	65	23	42
	E—8	103	58	45
	N—5	109	28	81
	C—12	92	45	47
	Top	81	38	43
Total	....	450	192	258
Per cent	....	...	42.7	57.3
B	E—8	71	21	50
	S—7	71	24	47
	N—6	70	28	42
	S—12	100	33	67
	Top	94	16	78
Total	....	406	122	284
Per cent	....	...	30	70
C	S—8	83	27	56
	E—9	60	7	53
	N—6	72	37	35
	C—14	87	19	68
	Top	70	16	54
Total	....	372	106	266
Per cent	....	...	28.5	71.5
D	N—6	65	19	46
	S—9	90	21	69
	E—7	73	29	44
	E—14	70	33	37
	Top	74	9	65
Total	....	372	111	261
Per cent	....	...	30	70
E	S—8	59	11	48
	W—4	69	13	56
	N—6	84	40	44
	C—12	59	30	29
	Top	106	18	88
Total	....	377	112	265
Per cent	....	...	29.7	70.3

It will be observed from the above table that fewer dead fruit spurs were found in the top of the tree than in any other portion, and a small per cent more in the center than on the sides of the tree. These differences are, however, much smaller than would ordinarily be expected in considering favorable and unfavorable locations for the development of a fungus, and serve to show how resistant this fungus is to adverse weather conditions. Many of the spurs considered alive will never bear fruit again, as they are badly weakened by blotch cankers. In determining a live from a dead spur,

the plan adopted was to count all spurs alive which had set a fruit bud during the past season, regardless of how badly it may have been blotched. A count was kept, in order to show the condition of the trees more closely, of the number of dead buds upon these live fruit spurs. In the following table the same notation is used as in the preceding, as the same limbs were used.

TABLE II.

Tree.	Position of limb.	Number live spurs.	Total number buds.	Dead buds.	Live buds.
A	S—6	42	89	31	58
	E—8	45	77	46	31
	N—5	81	89	32	57
	C—12	47	63	32	31
	Top	43	56	7	49
Total	....	258	374	148	226
Per cent	....	....	....	39.6	60.4
B	E—8	50	65	29	36
	S—7	47	70	24	46
	N—6	42	52	25	27
	S—12	67	75	20	55
	Top	78	85	15	70
Total	....	284	347	113	234
Per cent	....	....	....	32.6	67.4
C	S—8	56	66	40	26
	E—9	53	77	59	18
	N—6	35	67	56	11
	C—14	68	66	30	36
	Top	54	106	25	81
Total	....	266	382	210	172
Per cent	....	....	....	55	45
D	N—6	46	54	18	36
	S—9	69	90	19	71
	E—7	44	60	26	34
	E—14	37	44	27	17
	Top	65	82	11	71
Total	....	261	330	101	229
Per cent	....	....	....	30.6	69.4
E	S—8	48	84	17	67
	W—4	56	17	39	38
	N—6	44	51	23	28
	C—12	29	47	12	35
	Top	88	154	11	143
Total	....	265	413	102	311
Per cent	....	....	....	24.7	75.3

By considering both these tables, the importance of the disease upon the fruit spurs will be recognized. An average

of about one-third of the total fruit spurs are dead, and one-third of the total fruit buds upon the remaining spurs are dead. Even this proportion of injury is low, for many buds now apparently alive would not produce fruit. Cultures from these buds show several fungi, and no doubt in some cases their death might be charged to another cause, but by far the greater number are unable to live on account of the weakened, diseased condition of the fruit spur upon which they are borne.

Blotch upon the Fruit.

The multitude of spores which are liberated from the cankers during the summer insure an abundant opportunity for fruit infection. So great is the number of spores set free in the orchard containing many badly cankered trees, that the successful entrance of the fruit, by only a small per cent, would be sufficient for a total loss of the crop. Not all varieties, however, would be thus badly injured, even if unsprayed, for a few seem to possess a peculiar property of prohibiting the entrance of the germ tube. It has not been determined why this difference in susceptibility exists. The epidermis seems no more resistant to other fungi, in most cases, than that of the more susceptible varieties. It is not because they are slower growing, for many varieties badly affected with blotch grow much more slowly. The tree of the resistant varieties is not susceptible to blotch cankers, but this could not be considered a reason for the immunity of the fruit, as they are frequently found growing between badly cankered trees of other varieties, which would insure ample chance for infection. Even the leaves are almost proof against the blotch. Why certain varieties should be so much more susceptible than others will probably remain a mystery, as similar conditions have been noticed in the resistance of varieties to other fungi and no acceptable cause has been given.

First Appearance of the Disease.

The blotch injury first appears upon the fruit in from six to eight weeks after the petals fall. During the dry season of 1911 the first injury was noticed approximately eight weeks after the falling of the petals, while during the past season, which was much more favorable for any fungous growth, the first injury was noticed seven weeks after the petals fell. In this latter case the injury was apparently a week or more old

when found. The general supposition is that the infection period is later than it really is, on account of the late appearance of the disease, but the real cause for this delay is the slow growth of the fungus and the fact that the disease is not visible to the naked eye in its earliest state.

The first appearance of the injury varies somewhat with the variety attacked. The majority of the blotch spots are first noticed as a collection of brown fibers just beneath the skin or epidermis of the apple. These irregular brown threads become more and more numerous, becoming dense and changing to dark olivaceous in the older portion, and reaching out in a feathery fringe of lighter color around the margin. (Fig. 6.) Other blotches are first noticed as a dark, slightly

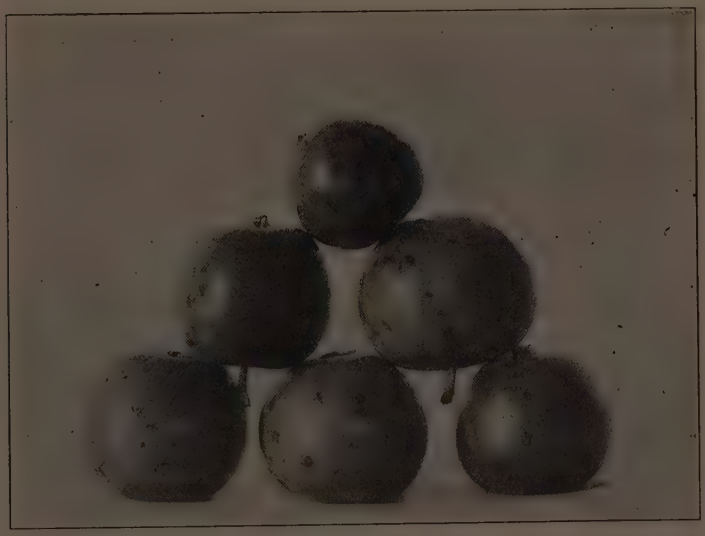


FIG. 6. Blotch as it appears during the fore part of July on a number of varieties. The apples shown are Ben Davis.

sunken spot, with or without a fringed margin. In this case the sunken portion usually advances steadily, retaining its regular outline. A stellate fringe of fibers frequently precedes this sunken injury as it enlarges. In a few cases, the first indication of injury is a raised, dark brown, irregular spot. Such a condition was noticed on Ben Davis apples during the past summer. Not infrequently, on light-colored varieties

the first spots appear green, later becoming brown, and upon dark red varieties the late injuries often appear first as a very dark red, changing later to black.

Whatever may be the first appearance of the disease, the ultimate results are always to disfigure and render the fruit unsightly and unsalable. The fungus does not ordinarily penetrate deeply into the fruit, but kills the cells just beneath the skin. Such a spot becomes brown or black in color, and frequently cracks severely as the uninjured cells below continue in growth. This kind of injury is especially common to the Ben Davis, and frequently the cracks extend almost to the core. Upon many varieties the injured spot becomes more or less sunken, either in small areas, giving the apple a pitted appearance, or in areas so large as to cover one-third or more of the fruit.

Apples badly affected with blotch are practically useless, as the disease renders them too dry for cider stock; and on account of the great waste they can not be profitably evaporated.

Something of the comparative severity of the blotch injury to a few varieties grown in Kansas may be gained from the following list. In each group they have been placed in the order of their susceptibility to the disease:

Severely injured: Missouri Pippin, Ben Davis, Limber Twig, Domine, Northwestern Greening, White Winter Pearmain, Huntsman Favorite, Arkansas Black, Maiden Blush, Smith Cider, Tolman Sweet, Fameuse, Wagener, Gano, Willow Twig, Gilpin, Mammoth Black Twig.

Moderately injured: McAfee, Ralls Genet, Yellow Bellflower, Ingram, Northern Spy, Stayman Winesap, Fink, Minkler, Wealthy, Rome Beauty.

Slightly injured: Jonathan, Grimes Golden, Winesap, York Imperial.

Description of the Injury Upon Individual Varieties.

The following descriptions of the early and later injury upon individual varieties is given with the hope that it may help many growers in distinguishing the blotch from other common fungi. The purpose is not to enable the orchardist to determine, by any such identification, the time to apply spray for the control of the blotch fungus; for an application made after the disease has entered and is visible upon the fruit

will not stop the injury. Such a spray would prevent the spread of the disease from this injured fruit, but if a regular outline is being followed for the control of blotch, it should prevent such liability of infection.

Missouri Pippin.

The injury starts as a small, solid brown spot or collection of brown fibers beneath the skin. After being visible a week or two the spot usually becomes sunken and retains a regular margin around this depressed area. A fringed, unsunken border may or may not be visible surrounding the sunken portion. Other forms of injury are a smooth, blackish, fringed blotch, and a combination of such a blotch and a pitted area. The usual form of injury is the smooth, depressed, regular, dark brown or black spot. *Injury very severe.* (Fig. 7.)

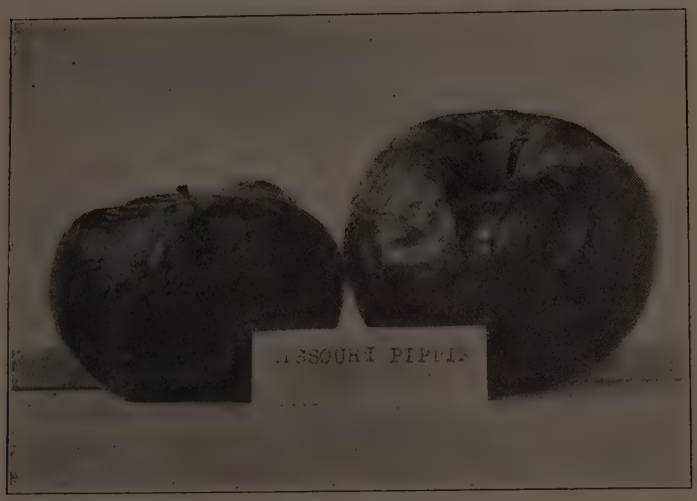


Fig. 7. Blotch on Missouri Pippin.

Ben Davis.

The first indication of blotch is a collection of brown fibers below the skin. Only one or two fibers may be visible or many may appear. The outline continues irregular or fringed and the spot usually is not sunken, though it may become so in some cases. Cracking almost always follows, the cracks often forming a T or cross. Injury very severe. (Fig. 8.)

Limber Twig.

The injury starts much as it does on the Missouri Pippin, but as the spot grows older it does not usually increase as much in extent. Frequent. Rather small sunken areas give the fruit a pitted appearance. Often a sunken area is surrounded by a raised portion, and this in turn by another sunken section, giving a crater-like appearance. The margin of the injury upon this variety may or may not be fringed. Injury very severe.

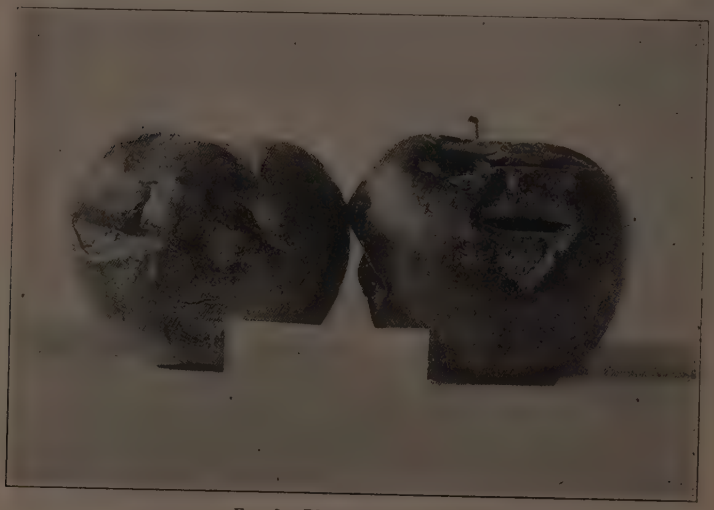


FIG. 8. Blotch on Ben Davis.

Domine.

The first indication of blotch upon the Domine is usually a discolored area, either green, brown, pinkish red, or yellowish. As growth proceeds the injury becomes roughened by shallow depressions, and the spots frequently crack severely. Often a spot upon a yellow cheek has a fringed light red margin. Injury very severe.

White Winter Pearmain.

The injury is noticed first as a solid brown spot, or fringed, brown, stellate collection. The later blotch may be smooth and much fringed or sunken and more regular. Cracking frequently occurs in severe cases. Injury very severe.

Huntsman Favorite.

The first appearance of injury is usually either a solid brown spot or solid spot surrounded by brown fringe. Later this area becomes sunken and smooth, retaining a regular margin or having a fringed outline. The blotch is very conspicuous, and frequently a red border surrounds the injury. Injury very severe.

Arkansas Black.

At first the spot is black, sunken and smooth, or simply a fringed blotch. Later the injured fruit is much pitted with large or small sunken spots having regular or dark fringed outline. Injury very severe. (Fig. 9.)

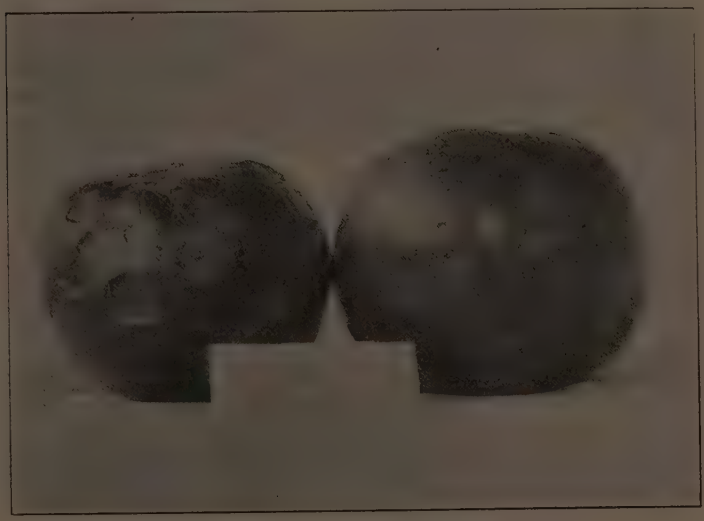


FIG. 9. Blotch on Arkansas Black.

Maiden Blush.

The spot is at first either red or brown and fringed. As the fruit increases the blotch spreads, much fringed, brown or dark brown. Such injury is very conspicuous and occasionally surrounded with a red margin. Injury severe.

Smith Cider.

The beginning of the injury is a collection of brown fibers, which spread into a much fringed or sunken, fairly regular spot. Occasionally the spot is quite light brown and feathery in appearance, but usually the blotch is large, dark, and conspicuous. Injury severe. (Fig. 10.)

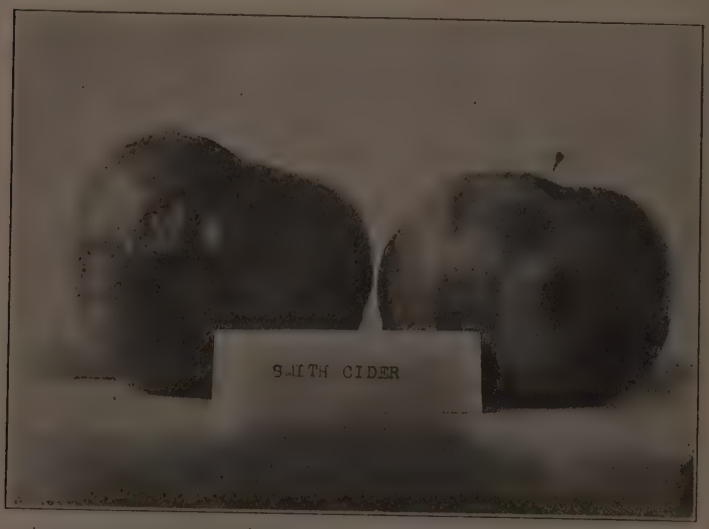


FIG. 10, Blotch on Smith Cider.

Tolman Sweet.

The injury in this case starts and retains a much fringed, brown, conspicuous appearance. In the more advanced stage the blotch is surrounded often with a green margin. Occasionally the spot appears slightly raised. Injury severe.

Fameuse.

A dark red spot on the red cheek or a brown collection of fibers on the uncolored section marks the first appearance of blotch upon this variety, commonly called Snow. An indistinct fringe usually surrounds the slightly sunken or smooth injury. Late in the season the blotched spot frequently becomes slightly mottled with yellowish brown. Injury severe.

Wagener.

The first appearance of the injury has not been determined for this variety. The blotch on the mature apple varies from much sunken with a regular distinct outline to an unsunken spot varying from light to dark brown, and surrounded frequently with red. Injury severe.

Gano.

Injury starts as a condensed or stellate brown spot. Often two or three shades of red and brown alternate around the central spot, which is dark and rough or smooth. The bloom often causes the spot to appear blue or purple. Injury severe.

Willow Twig.

The early injury consists of a brown, feathery collection or as a condensed brown spot with fringed margin. Later the blotch may be slightly sunken with a fringed outline surrounding, or simply a dark brown irregular spot. Occasionally a yellow discoloration appears around the blotch spot. Injury severe.

Gilpin.

At first the spots are brown and stellate, later changing, usually to sunken, and having a smooth, regular outline. A few large stellate blotches appear on the mature fruit also. Injury severe.

Mammoth Black Twig.

Black or brown condensed spots are usually first noticed on the red cheek, or a brown collection of fibers on the uncolored portion. Usually but one to two or three blotches appear on an apple, and are not very conspicuous, especially when the fruit is well colored. The center of the spot is slightly pitted and a dark irregular fringe surrounds the injury. (Fig. 11.)

McAfee.

At first appearing as a greenish or reddish brown spot, the injury later becomes dark brown and roughened by numerous pits. Frequently a reddish pink surrounds the blotch spot.

Lawver.

The young spot may be either slightly sunken and dense or smooth and stellate. It is usually a green or reddish brown at first, later changing to dark brown or reddish purple, surrounded by lighter margin.

Ralls Genet.

Starts and continues as a bundle of fibers, light to dark brown in color.

Ingram.

Similar to Ralls Genet.

Northern Spy.

Injury similar to Domine, but much less severe.

Stayman Winesap, Fink, Minkler, and Rome Beauty.

These are injured in much the same manner. The stellate collection of brown mycelium spreads with a feathery, irregular edge. Usually the spots are smooth, but occasionally may be slightly sunken. The injury is usually not severe.

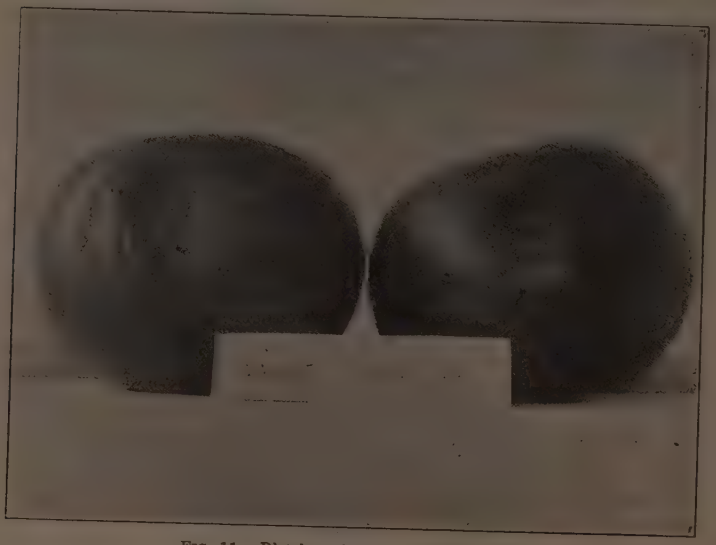


FIG. 11. Blotch on Mammoth Black Twig

Wealthy.

The injury to the Wealthy is similar to that of the Gano, but much less severe.

Jonathan and Grimes Golden.

The first appearance of injury is a collection of brown fibers. Occasionally the spot upon Jonathan may become cracked, but usually is slightly rough and fringed. The blotch enlarges slowly and remains fringed on Grimes Golden.

FIG. 20. Blotch in successive stages upon the Ben Davis.

Winesap and York Imperial.

These two varieties are most resistant to the attacks of the blotch, but occasionally a few spots may appear upon them. The spot is first seen on the Winesap as a brown, fringed discoloration, which may become slightly sunken in spots or remain smooth. The same appearance marks its first growth upon the York Imperial, but later the spot becomes slightly sunken.

Review of 1910.

During the season of 1910 the departments of horticulture and entomology, in coöperation with the United States Department of Agriculture, carried on a series of spraying demonstrations in eight widely separated orchards in the eastern part of the state. The purpose of these tests was to control all insects and fungi, and the blotch was given no more prominence in this general work than any other disease. The relative values of Bordeaux and lime and sulphur as a fungicidal spray was, however, one of the important points considered, and as varieties were included in the tests which were susceptible to the blotch fungus, this portion of the data obtained, where comparable blocks were secured, is of the same value as though especially planned for this test only. In addition to this general outline, a special experiment was carried on for the control of the blotch fungus. In this latter case an orchard of badly infested Missouri Pippins was chosen for treatment, the purpose being to compare the values of Bordeaux and lime-sulphur, applied two or three times each.

Results Obtained in the General Test.

The schedule adopted for the general spraying tests called for four applications of spray, the first as the cluster buds opened, but before blossoming; the second as soon as the majority of the petals had fallen; the third three weeks after the falling of the petals; and the fourth ten weeks after the falling of the petals. The Bordeaux used contained three pounds of copper sulphate, four pounds of lime to fifty gallons of water, and the lime-sulphur was used at the rate of one and one-half gallons of concentrated commercial solution to fifty gal-

lons of water. Each contained also two pounds of arsenate of lead to fifty gallons of the spray material.

The orchards were so divided that three similar plats could be obtained in each variety, one of which was treated with Bordeaux mixture, another with lime-sulphur, and the third was not sprayed, being retained as a check. Care was used in selecting these plats, with the view of having them as nearly comparable in every way as possible. On account of the susceptibility of the Ben Davis and Missouri Pippin varieties, the most of the tables have been selected from the data obtained in the treatment of these varieties.

The following tables include the data obtained in the Ben Davis block of the Buckmaster orchard at Fort Scott, Kan. The first application (the cluster cup) of the schedule was omitted, but as this is not important in the control of blotch, the results are not marred thereby.

TABLE No. 3.—Ben Davis block.

PLAT I.—Bordeaux treatment.

	Total number apples.	Number apples blotched.	Per cent blotch.	Spray injury.	Per cent spray injury.
Windfalls	387	12	3.10	144	37 2
Picked	2,051	38	1 85	.....	.....
Totals	2,438	50	2.05	144	5.9

PLAT II.—Lime and sulphur treatment.

Windfalls	500	66	13.20	73	14.6
Picked	3,175	894	28 10	.....	.....
Totals	3,675	960	26.10	73	1.9

PLAT III.—No spray.

Windfalls	911	320	35 10	.....	.....
Picked	858	514	59.90	.....	.....
Totals	1,769	834	47 10	.....	.....

The plat sprayed with Bordeaux shows remarkable control, only 2.05 per cent being affected with blotch, while in the unsprayed plat 47.1 per cent were blotched. Plat No. II, treated with lime-sulphur, shows more than one-half as much injury as the check plat.

A block of Missouri Pippins in the same orchard was treated in the same manner as the Ben Davis, and a summary of the results appear in table No. 4.

TABLE NO. 4.—Missouri Pippin block.

PLAT I.—Bordeaux treatment.

	Total number apples.	Number apples blotched.	Per cent blotch.	Spray injury.	Per cent spray injury.
Windfalls	1,317	777	58.9	61	4.60
Picked	4,860	1,968	40.4	150	3.08
Totals	6,177	2,745	44.4	211	3 40

PLAT II.—Lime-sulphur treatment.

Windfalls	5,193	4,581	88.2	27	.50
Picked	1,201	466	38 8		
Totals	6,394	5,047	78.9	27	.40

PLAT III.—No spray.

Windfalls	2,819	2,766	98 1		
Picked	65	43	66.1		
Totals	2,884	2,809	97.3		

A similar relation between the control effected in the three plats in this table and those similarly sprayed in table No. 3 are noticed. It also seems from these data that control can not be expected by the schedule used, when the unsprayed trees show above 90 per cent of blotch.

A general summary obtained from all eight of the orchards treated, and comprising the results from spraying the several varieties found in these orchards, shows Bordeaux mixture to be much more effective than lime-sulphur in blotch control:

TABLE NO. 5.—Per cent of blotch upon all varieties combined.

Bordeaux spray	7.42%
Lime-sulphur spray	13.35
No spray	23.8

RESULTS OBTAINED BY SPECIAL TEST.

Recognizing the importance of the apple blotch and the difficulty usually reported in its control, an experiment was especially planned for further testing the relative values of Bordeaux and lime-sulphur. The Snyder & Roediger orchard at Parker, Kan., contained a large block of badly infested Missouri Pippins, which were selected for this test. The following, quoted from the Kansas bulletin No. 174, will show the result of this work:

A block of 150 Missouri Pippin trees, located in the midst of a 100-acre orchard of the same variety, was selected for the experiment. This block

was so chosen that each of the rows composing it would be subjected apparently to exactly the same environment, and it was divided into five rows. The first received no treatment whatever, the second was thoroughly sprayed twice with 3-4-50 Bordeaux, the first treatment being given at the dropping of the petals and the second treatment three weeks later. The third was sprayed thoroughly three times with 3-4-50 Bordeaux, the first spray being applied at the dropping of the petals, the second three weeks later, and the third ten weeks after the first. The fifth was sprayed two times with one and one-half gallons of commercial lime-sulphur to 50 gallons of water, the first spray being given at the dropping of the petals and the second three weeks later. The fourth was sprayed three times with one and one-half gallons of commercial lime-sulphur solution to 50 gallons of water, the first being applied at the dropping of the petals, the second three weeks later, and the third ten weeks after the first. In all cases the mixtures were delivered as a mist, under a pressure ranging from 120 to 180 pounds, with a gas-engine sprayer, and an especial effort was made to give the trees in every case an even and continuous coat. Arsenate of lead at the rate of 2 pounds to 50 gallons of water was used in the first two sprayings of each row. Although the check received no poison, and the commercial results are on that account open to suspicion as being modified by insect injury, careful observation has convinced us that apple blotch is mainly to blame for the low commercial yield of the check. The following tables will show the results of this treatment in commercial returns and in counts made of the individual apples:

RETURNS in merchantable fruit as "orchard run."

Row.	TREATMENT.	Per cent merchantable fruit.
1.....	None.	13.0
2.....	Bordeaux twice	59 0
3.....	Bordeaux three times	83.5
5.....	Lime-sulphur twice	57.0
4.....	Lime-sulphur three times	57.0

RETURNS in merchantable fruit when graded into 1's, 2's, and salable culls.

Row.	TREATMENT.	Per cent merchantable fruit which graded—		
		1's.	2's.	Salable culls.
1.....	None	0.0	17 6	82.4
2.....	Bordeaux twice	3 4	64.4	32.2
3.....	Bordeaux three times	18.2	54 5	27.3
5.....	Lime-sulphur twice	5.0	41.8	53.2
4.....	Lime-sulphur three times	18 8	48.7	32 5

EFFECTS of spray as determined by examination of every apple which set on each of four trees from each row.

Row.	TREATMENT.	Per cent of apples free from apple blotch.		
		Windfalls.	Picked.	Total.
1.....	None	11.6	12 6	11 7
2.....	Bordeaux twice	36.9	52.0	45.1
3.....	Bordeaux three times	61.6	77.3	72.0
5.....	Lime-sulphur twice	15.7	20 5	16 5
4.....	Lime-sulphur three times	25.0	48 8	34 5

Some interesting points are contained in these tables. In the first an increase of 24.5 per cent merchantable fruit is the result of three sprays of Bordeaux, over the amount obtained by two sprays of Bordeaux. There is no difference between two and three sprayings with lime-sulphur, and only 2 per cent gain by the use of two sprayings with Bordeaux in place of two sprayings with lime-sulphur. However, three sprayings with Bordeaux show an increase of 26.5 per cent over three sprayings with lime-sulphur. Two applications of Bordeaux controlled better than three applications of lime-sulphur.

Similar differences are obtained in favor of Bordeaux from the last table. Two applications of Bordeaux again show a better result than three applications of lime-sulphur. Three treatments with Bordeaux show a gain of 26.9 per cent over two treatments with Bordeaux, and a gain of 37.5 per cent over three treatments with lime and sulphur.

SUMMARY FOR 1910.

The general results obtained by this work may be summarized as follows:

Bordeaux mixture is a more effective fungicide for the control of apple blotch than is lime-sulphur.

The schedule used does not give control when the check trees show 75 per cent or more blotched fruit.

Either additional sprayings or the changing of the dates of application will be necessary to effectively control the blotch in badly infected orchards.

Since Bordeaux mixture is liable to cause serious burning, the possibility of controlling the blotch with some other fungicide should be tested further.

Review of 1911.

The spring and summer of 1911 were characterized by extremely dry and hot weather. During much of the time drying winds swept through the orchards, making it apparently impossible for any fungus spores to germinate and grow. The few small showers which occurred did not remain long on the trees, as the sun almost invariably followed closely in their wake.

Spray outlines were planned for three orchards, but owing to the unfavorable weather conditions for the growth of fungi, the entire schedule was carried out in only one. The orchards treated were the Ingram and Kimball orchards, near Manhattan, and part of the Yaggy orchard, near Hutchinson. Only in this latter place was the entire schedule followed out.

The general plan of the work for this season included: the further testing of Bordeaux and commercial lime-sulphur, both separately and combined in the same schedule; a test of home-boiled lime-sulphur; applications of Bordeaux which contained less than 3 pounds of copper sulphate, and the use of commercial lime-sulphur containing more than 1½ gallons of the concentrate to 50 gallons of water.

The object of the work was, of course, to determine what material would give the best control of the blotch fungus with the least amount of injury to the fruit.

The Manhattan Orchards.

Only one spray intended to control the blotch fungus was applied in either of the Manhattan orchards. This application was made 14 days after the petals were down, and the following applications, scheduled for 4 weeks and 7 weeks, respectively, after the falling of the petals, were omitted, as it seemed at that time that they would not be needed. Undoubtedly the majority of the fungus spores liberated in the orchard either did not germinate or were killed before gaining entrance to the fruit, but the blotch seemed but little checked by the adverse conditions, the unsprayed trees in the Missouri Pippin block of the Ingram orchard showing over 90 per cent of injury, and those in the Kimball orchard 70 per cent.

The early applications were all made according to the schedule, with a Deming pump driven by a Fairbanks-Morse engine. No doubt these early applications aided in the blotch control, as no rain had fallen to wash them from the trees, and they were still plainly visible late in the season. A pressure of 175 to 200 pounds was maintained, and the solution was applied in the form of a mist. Great care was taken to reach every part of each tree, but to avoid drenching the leaves and fruit, as by overspraying, less of the mixture was found to remain upon the tree.

Ingram Orchard.

An examination of the outline of sprays scheduled for this orchard shows a test, in both the Missouri Pippin and Ben Davis blocks, of home-boiled lime-sulphur, commercial lime-sulphur, and Bordeaux mixture. The home-boiled lime-sulphur was made by boiling 15 pounds of lime and 20 pounds of sulphur together in an iron kettle for 45 minutes, and diluting to 50 gallons, for the dormant spray; and by using 20 pounds each of lime and sulphur and diluting to 150 gallons for the later applications. The commercial concentrate was added to enough water to satisfy the formula (3 gallons of the concentrated lime-sulphur to 47 gallons of water for the dormant spray, and 1½ gallons of the concentrated lime-sulphur to 48½ gallons of water for the later sprayings) and thoroughly mixed before applying. Great care was taken in making the Bordeaux mixture. Only a good grade of stone lime was used, and it was slowly and carefully slaked. The copper sulphate was dissolved by suspending in the top of a barrel of water. This milk of lime and copper sulphate in solution were then added, each to one-half the full amount of water, and these two dilute solutions were poured together or allowed to run together into the spraying tank. As separate experiments were being conducted in the blocks sprayed, for the control of insects, no poison of any kind was added to any of the fungicides applied.

In addition to the spray solutions described above, Bordeaux mixture of the strength 3-4-50 was applied at various intervals to three of the Missouri Pippin rows, and Bordeaux of the strength 2-4-50 to one of the Ben Davis rows.

All results from this work are based upon individual counts of from one to three or four trees located in the treated row. The windfalls, as well as the picked fruit, were examined at intervals throughout the summer, and these results were combined with those from the picked fruit, both being included in the table. The "total number of fruit" will be observed to vary considerably, but this variance is due to the number of count trees used rather than to the effect of the fungus.

SPRAY OUTLINE for Ingram orchard, 1911.

MISSOURI PIPPIN.

Row.	Dormant.	Cluster-cup.	Blossom-fall.	14 days.
A	Home-boiled L-S. 15-20-50.	Home-boiled L-S. 20-20-150.	Home-boiled L-S. 20-20-150.	Home-boiled L-S. 20-20-150.
B	Commercial L-S. 3-50.	Commercial L-S. 1½-50.	Commercial L-S. 1½-50.	Commercial L-S. 1½-50.
C	Copper sulphate. 6-50.	Bordeaux. 3-4-50.	Bordeaux. 3-4-50.	Bordeaux. 3-4-50.
D		Bordeaux. 3-4-50.		
E			Bordeaux. 3-4-50.	
F				Bordeaux. 3-4-50.

BEN DAVIS.

G	Home-boiled L-S. 15-20-50.	Home-boiled L-S. 20-20-150.	Home-boiled L-S. 20-20-150.	Home-boiled L-S. 20-20-150.
H	Copper sulphate. 6-50.	Bordeaux. 4-6-50.	Bordeaux. 3-4-50.	Bordeaux. 3-4-50.
J	Bordeaux. 6-6-50.	Bordeaux. 2-4-50.	Bordeaux. 2-4-50.	Bordeaux. 2-4-50.

TABLE No. 6.—Effect of sprays as determined by individual examination of each apple which set on several trees in each treated row.

VARIETY.	Row.	Total fruit.	Blotch.	Per cent blotch.	Spray injury.	Per cent spray injury.
Missouri Pippin	A	1,293	361	27 8		
"	B	3,010	1,083	35 9		
"	C	6,672	980	14 7	91	1.5
"	D	6,059	4,946	81 3		
"	E	9,634	7,702	80		
"	F	2,747	1,566	57		
"	Check.	3,592	3,273	91.1		
Ben Davis	G	2,142	1,288	60.1	28	2.2
"	I	3,023	491	16.2		
"	H	1,486	90	6.1		
"	J	2,938	494	16 8		
"	Check.	643	464	72.16		

The Kimball Orchard.

Bordeaux mixture and commercial lime-sulphur were each used in two different strengths in this orchard, also a combination of the two was tried in the treatment of a row each of Missouri Pippins and Ben Davis. These mixtures were all made in the same manner as those applied in the Ingram orchard. Self-boiled lime-sulphur was tried on one row of Missouri Pippins and reduced the blotch injury materially. The lime was placed in an open barrel and started slaking; the sulphur, which had previously been mixed into a thin paste with water, was then added, and the whole mass was well mixed. Water was added and the mixture was stirred as necessary to prevent burning, and as soon as the slaking process was well over the barrel was filled with water. The solution was then well stirred and strained into the spraying tank.

The results from this orchard show better control by all mixtures than do those from the Ingram orchard. It must be remembered, however, that the check trees in this orchard show but 70 per cent of injury, while those of the Ingram orchard show 90 per cent. On this account better control should be expected, since the difference in infection is much less.

SPRAY OUTLINE for Kimball orchard, 1911.

MISSOURI PIPPIN.

Row.	Cluster-cup.	Blossom-fall.	14 days.
F	Bordeaux. 4-6-50.	Bordeaux. 3-4-50.	Bordeaux. 3-4-50.
R		Bordeaux. 4-5-50.	Bordeaux. 4-5-50.
E	Bordeaux. 4-6-50.	Commercial L-S. 1½-50.	Commercial L-S. 1½-50.
S	Commercial L-S 1½-50.	Commercial L-S. 1½-50.	Commercial L-S. 1½-50.
T		Commercial L-S. 2-50.	Commercial L-S. 2-50.
Q	Self-boiled L-S. 10-10-50.	Self-boiled L-S 10-10-50.	Self-boiled L-S. 10-10-50.

BEN DAVIS.

C	Bordeaux. 4-6-50.	Bordeaux. 3-4-50.	Bordeaux. 3-4-50.
B	Bordeaux. 4-6-50.	Commercial L-S. 1½-50.	Commercial L-S. 1¼-50.

TABLE No. 7.—Effect of sprays as determined by individual examination of each apple which set on several trees in each treated row.

VARIETY.	Row.	Total fruit.	Blotch.	Per cent blotch.	Spray injury.	Per cent spray injury.
Missouri Pippin..	F	4,253	317	7.5		
" ..	R	2,204	124	5.6		
" ..	E	2,401	294	12.2		
" ..	S	2,930	243	8.3		
" ..	T	2,838	208	7.3		
" ..	Q	5,001	1,377	27 5		
Ben Davis.....	C	6,976	250	3.6	228	3.3
"	B	5,645	180	3.2		
Missouri Pippin...	Check.	1,250	878	70.24		

From the results obtained from these two orchards it will be observed that Bordeaux 3-4-50 again proves to be the most efficient fungicide. Bordeaux of the strength 2-4-50 controlled no better than commercial lime-sulphur, and while two applications of 4-5-50 Bordeaux gave good control without any burning, a wet season would probably have resulted in some injury. The 3-4-50 Bordeaux applied to rows D, E and F of the Ingram orchard shows a much better control by the fourteen days' application than by either of the other two. The self-boiled lime-sulphur did not prove satisfactory for blotch control.

SPRAYING TESTS AT HUTCHINSON.

The Yaggy Orchard.

The spray outline, for the portion of the Yaggy orchard treated, was planned much as the general work of 1910, to control all fungi and insects. The results will, therefore, be presented in part only. From four of the plats treated data were obtained which has a direct bearing on the points considered during this season. Plats I and II were arranged for the test of Bordeaux and commercial lime-sulphur, while III and IV contain interesting data on the combination of these two fungicides. It will be observed, by examining the data from the check trees, that the chance for blotch infection was only about one-half as great as in the Manhattan orchards. For this reason, and the fact that later sprays were applied in this orchard, better control was effected here than at either the Kimball or Ingram orchards.

The weather was exceedingly hot and dry at this orchard during the summer. During the week, however, when the

petal-fall spray was being applied, the following notes were taken: "When this spraying started, May 1, the petals were nearly all down. It was very cold the first, with a little north wind. The second was similar, but the wind had shifted to the east. Rain and continued wet weather prevented the entire completion of the spraying until the seventh, which was warm with a strong south wind." From these notes taken by the observer at the orchard, the conditions under which this spray was applied are seen to be excellent for Bordeaux burning. Later, as the season became intensely hot, the conditions were equally good for lime-sulphur-lead burning. This combination of circumstances makes the experiment outlined in plats III and IV of great interest, since this was an exaggerated form of the ordinary Kansas season.

The work was so arranged that a plat of Ben Davis trees and an equal number of Missouri Pippin trees received the same treatment. The same methods were used in mixing the spray materials as those employed in the Manhattan orchards, and the same care was taken in the application, to cover all parts of each tree.

The spray was applied as a mist, with a gasoline power sprayer, the early applications being made with a Deming and the later with a New-Way outfit, and a pressure averaging about 200 pounds was maintained.

In comparing the efficiency of Bordeaux and lime-sulphur in plats I and II, a row of Ben Davis and one of Missouri Pippins each received the treatment outlined for row 1; another row of each variety received the outlined treatment for row 2, etc., throughout the schedule.

The results are recorded in different tables, in order to show the results of the treatment upon each variety. In the following outline "Bx + Pb" indicates Bordeaux 3-4-50 to which 3 pounds of arsenate is added.

PLAT I.—Spray outline.

	Cluster-cup.	Blossom-fall.	10 days.	21 days.	70 days.
Row 1	Bx+Pb	.....	.....	.....	.....
Row 2	Bx+Pb	Bx+Pb	.....	.....	.....
Row 3	Bx+Pb	Bx+Pb	Bx+Pb	.....	.....
Row 4	Bx+Pb	Bx+Pb	Bx+Pb	Bx+Pb	.....
Row 5	Bx+Pb	Bx+Pb	Bx+Pb	Bx+Pb	Bx+Pb

TABLE No. 8.—Efficiency of Bordeaux mixture for the control of the blotch, as indicated by individual examination of every apple set on two trees in each treated row

VARIETY.	Row.	Total fruit.	Blotch.	Per cent blotch.	Spray injury.	Per cent spray injury.
Ben Davis	1	1,715	379	22.09	.....	.....
"	2	834	12	1.42	327	39.2
"	3	1,995	5	.25	1,093	54.8
"	4	2,227	14	.63	1,058	47.5
"	5	3,647	12	.33	1,098	30.1
"	Check.	2,173	490	22.55	.....	.....
Missouri Pippin	1	2,876	951	33.07	.....	.....
"	2	5,412	809	14.85	109	20.1
"	3	3,236	40	1 24	587	18.1
"	4	4,472	83	1.86	734	16 4
"	5	6,130	95	1.55	1,106	18.0
"	Check.	4,485	2,447	54.55	.....	.....

The general arrangement of the outline and data tables for plat II is the same as for plat I. "L-S+Pb" indicates commercial lime-sulphur at the rate of 1½ gallons to 50 gallons of water to which 3 pounds of arsenate of lead is added.

PLAT II.—Spray outline.

	Cluster-cup.	Blossom-fall.	10 days.	21 days.	70 days.
Row 1	L-S+Pb	.....	.....	.....	.....
Row 2	L-S+Pb	L-S+Pb	.....	.....	.....
Row 3	L-S+Pb	L-S+Pb	L-S+Pb	.....	.....
Row 4	L-S+Pb	L-S+Pb	L-S+Pb	L-S+Pb	.....
Row 5	L-S+Pb	L-S+Pb	L-S+Pb	L-S+Pb	L-S+Pb

TABLE No. 9.—Efficiency of commercial lime-sulphur for the control of the blotch, as indicated by individual examination of every apple which set on two trees in each treated row.

VARIETY.	Row.	Total fruit.	Blotch.	Per cent blotch.	Spray injury.	Per cent spray injury.
Ben Davis	1	1,329	172	12 86	.....	.....
"	2	1,737	54	3.10	4	.23
"	3	1,878	172	9.10	32	1.70
"	4	2,612	2	.08	444	17 00
"	5	2,338	1	.04	546	23 30
"	Check.	2,173	490	22.55	.....	.....
Missouri Pippin	1	5,846	3,816	65 28	.....	.....
"	2	4,908	1,728	35 20	5	.29
"	3	3,631	499	13.74	23	.63
"	4	4,767	91	1.91	597	12.50
"	5	2,718	24	.88	372	13.60
"	Check.	4,485	2,447	54.55	.....	.....

The data obtained from plats I and II show little advantage in favor of either spray solution used in the control of the blotch fungus. The cumulative effect of the early applications is noticed throughout both of these tables, and would indicate that Bordeaux mixture remains effective the longer period of time, under the same conditions. The per cent of injury caused by the spray is less in the lime-sulphur than in the Bordeaux-treated plat, and the late applications of lime-sulphur cause the greatest injury, while as the Bordeaux injury remains fairly constant throughout, it is evident that the early applications of this fungicide cause the majority of the injury.

As a similar relation of the time of the application to the per cent of injury had been repeatedly noticed prior to this season, plats III and IV were outlined to obtain exact data on this subject. The following outlines and tables indicate the plan and results of this investigation. The spray mixtures were used at the same strengths as in the previous tests, and arsenate of lead was again added to each.

PLAT III.—Spray outline.

	Cluster-cup.	Blossom-fall.	10 days.	21 days.	70 days.
Row 1.....	Bx+Pb	Bx+Pb	L-S+Pb	L-S+Pb	L-S+Pb
Row 2.....	Bx+Pb	Bx+Pb	Bx+Pb	L-S+Pb	L-S+Pb
Row 3.....	Bx+Pb	Bx+Pb	Bx+Pb	Bx+Pb	L-S+Pb

TABLE No. 10.—The effect of the use of Bordeaux during the early part of the season, and commercial lime-sulphur during the latter part.

VARIETY.	Row.	Total fruit.	Blotch.	Per cent blotch.	Spray injury.	Per cent spray injury.
Ben Davis.....	1	3,424	3	.09	1,168	34.1
"	2	3,380	23	.69	1,168	34 5
"	3	3,629	11	.30	1,527	42.1
"	Check.	2,173	490	22.55	.....	.....
Missouri Pippin...	1	3,199	12	.37	950	29.7
" ...	2	4,612	32	.69	1,922	41.6
" ...	3	4,622	24	.52	386	8.4
" ...	Check.	4,485	2,447	54 55	.....	.....

PLAT IV.—Spray outline.

	Cluster-cup.	Blossom-fall.	10 days.	21 days.	70 days.
Row 1.....	L-S+Pb	L-S+Pb	Bx+Pb	Bx+Pb	Bx+Pb
Row 2.....	L-S+Pb	L-S+Pb	L-S+Pb	Bx+Pb	Bx+Pb
Row 3.....	L-S+Pb	L-S+Pb	L-S+Pb	L-S+Pb	Bx+Pb

TABLE No. 11. — The effect of the use of commercial lime-sulphur during the early part of the season, and Bordeaux during the latter part.

VARIETY.	Row.	Total fruit.	Blotch.	Per cent blotch.	Spray injury.	Per cent spray injury.
Ben Davis.....	1	5,160	11	0.21	481	9.30
"	2	3,287	5	.15	34	1.03
"	3	2,790	27	.97	735	26.30
"	Check.	2,173	490	22 55	.....	.....
Missouri Pippin..	1	4,223	30	71	626	14.80
" ..	2	7,307	51	.69	166	2.27
" ..	3	7,334	287	3.90	654	8.90
" ..	Check.	4,485	2,447	54 55	.....	.....

A comparison of the tables obtained from this test leaves little doubt as to the time of the applications of each fungicide causing the greatest burning. The treatment outlined for row 2 in plat IV indicates that a safe, efficient fungicide may be obtained by the use of lime-sulphur during the fore part of the season and Bordeaux during the latter part. The fact that Bordeaux burning is greatest when a spell of damp, cloudy weather follows its application, and that the conditions conducive to the burning of the lime-sulphur-lead mixture is bright, hot weather, would necessitate a variance of the schedule to suit the weather conditions.

SUMMARY.

In the majority of the tests of this season Bordeaux mixture again proved to be the most efficient fungicide for the control of the blotch, but its use is attended by some risk, owing to its liability to russet the fruit during damp weather. The application of spray two to four weeks after the falling of the petals controlled a larger per cent of blotch than any other one application.

The apple-blotch fungus is not materially checked by unfavorable weather conditions, and spray must be applied each year for its control.

The use of lime-sulphur during damp weather and Bordeaux during dry weather seems advisable.

Review of 1912.

The work of the past season in the control of the blotch fungus was outlined with a view of testing two methods of control. The first comprised an attempt to decrease by pruning the source from which infection occurs, and the second an experiment to determine the most important dates for the early applications of spray.

Both of these experiments were carried on in the Ingram orchard, the blocks used for the spraying test being the same as those treated during 1911, and the Missouri Pippin block alone being chosen for the pruning experiment. The season was normal, but the subsoil contained less than the usual amount of water on account of the drouth of the previous year.

The Pruning Experiment.

It was noticed during the summer of 1911 that the great number of cankers in the Missouri Pippin block of the Ingram orchard insured almost total infection of the unprotected fruit. Over 90 per cent of the apples from the check trees of this block were badly blotched, while the unsprayed trees of the

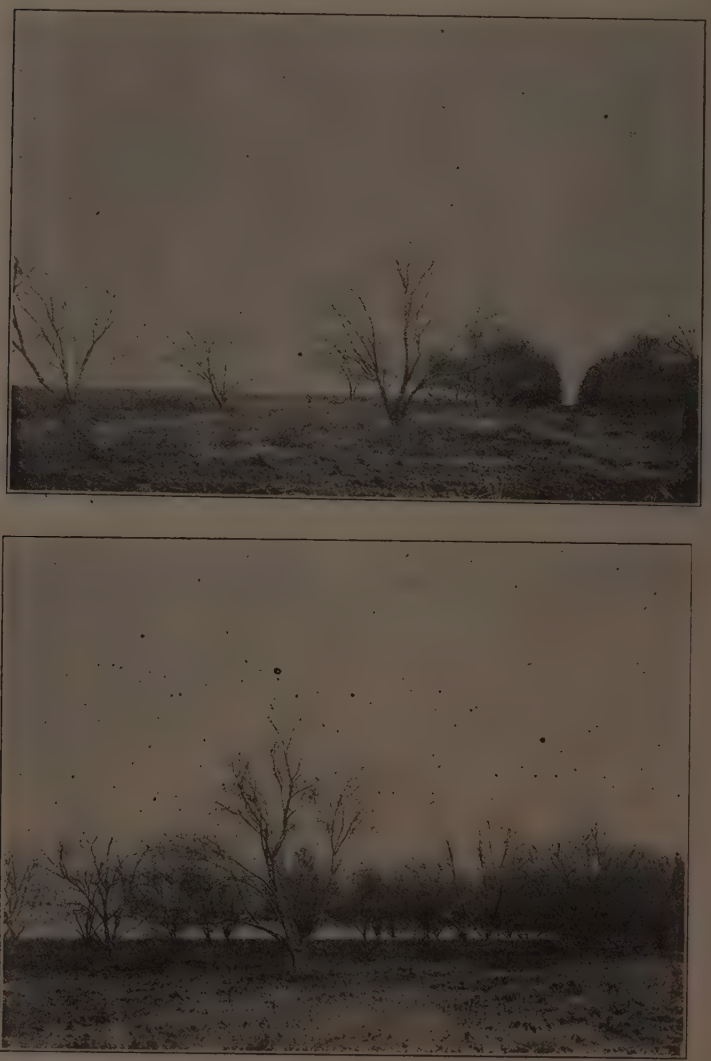
Fig. 12. The long slender limbs of the Missouri Pippin tree break frequently under the load of fruit. If allowed to grow unpruned the trees become tall and weak.

same variety in the Kimball and Yaggy orchards showed but 70 per cent and 54 per cent, respectively. The average control of the blotch in each of these orchards was noticed to be inversely proportional to this percentage, and the possibility of ridding the badly infested trees of many of the cankered limbs, thus lessening the chance of infection, was suggested.

The tall, slender habit of growth of the Missouri Pippin tree, and the fact that the limbs, being slender and weak, frequently break under a load of fruit, made it seem likely that this variety would be benefited by a process of pruning which would lower the head of the tree and strengthen the limbs. (Fig. 12.) Such a pruning, if carefully done, would not only rid the tree of many cankered and useless limbs, but also stiffen the general framework, and, by lowering the bearing surface, facilitate spraying and picking. It would not be possible to eliminate blotch from the orchard by removing all cankered limbs, but if one-fourth or one-fifth of the worst affected limbs could be removed from each tree, the disease would be more easily controlled by spraying.

In order to test the result of such a method of pruning, trees were selected at various intervals throughout the Missouri Pippin block, and cut back just before the leaf buds unfolded in the spring. One portion of the pruned trees were cut lightly, the work being done with pruning shears, and only the smaller limbs removed. Another portion was cut rather severely; frequently four to six or eight feet of the tallest slender limbs were removed, while the worst-affected side limbs were also shortened in. The remainder of the trees cut back received a medium pruning, being cut heavier than the first, but not so heavy as the second group. Care was taken in all this pruning not to remove more bearing wood than was necessary, fruit spurs and small side limbs being left wherever possible. An effort was made to spread the tops of the erect trees by leaving an outgrowing limb just below each cut. In several lopsided trees a balance was restored by pruning one side more severely than the other. As many of the trees had long, slender main branches, devoid of bearing wood for a considerable distance from the trunk, an effort was made to correct this condition by removing the heavy limbs farthest out, and leaving all limbs, large and small, nearer the trunk. This

process enables the trees to carry a good load of fruit without bending or breaking, as the Missouri Pippin limbs commonly do. (Figs. 13-14.)



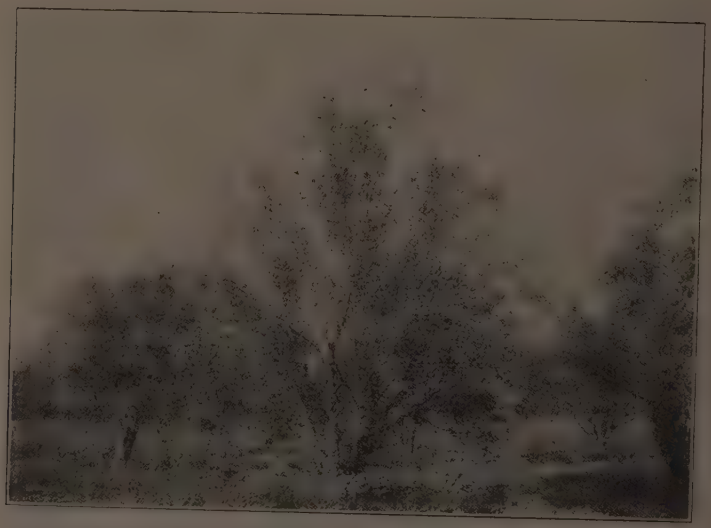
FIGS. 13, 14. The method of cutting back Missouri Pippin trees to reduce the number of blotch cankers and strengthen the limbs. Notice the side branches and fruit spurs left wherever possible.

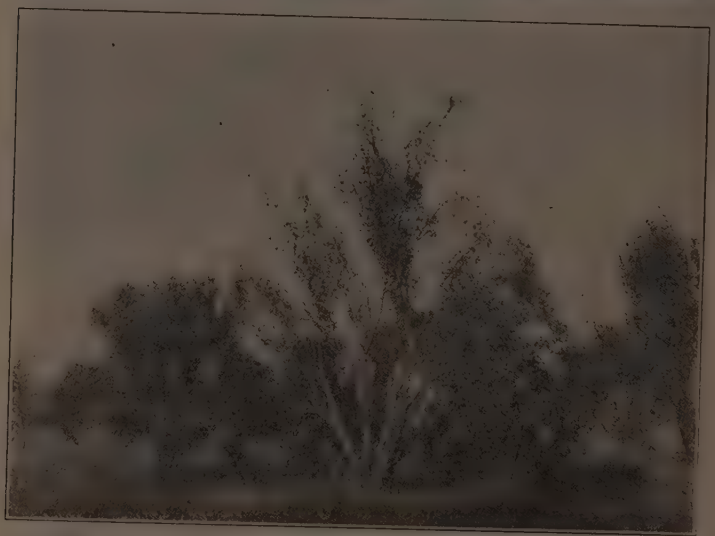
This work was done, not so much to lessen the possibility of blotch infection this year, as to note the result of such treatment to the tree itself. Removing a large number of blotch cankers from each pruned tree would, of course, reduce the chance for infection to a certain extent, but since the trees were usually surrounded by others which had not been pruned, no marked reduction in the per cent of blotch was noticed.

The first visible evidence of a difference between the pruned and unpruned trees was noticed about the time the leaves had reached their normal size. The leaves of the cut-back trees were larger and darker green than those of the unpruned trees, and the young shoots were making a much more vigorous growth. The fruit soon began to show this difference in size also, and during the remainder of the season much difference was noticed in the size of the fruit on a cut and uncut tree. (Fig. 15.)

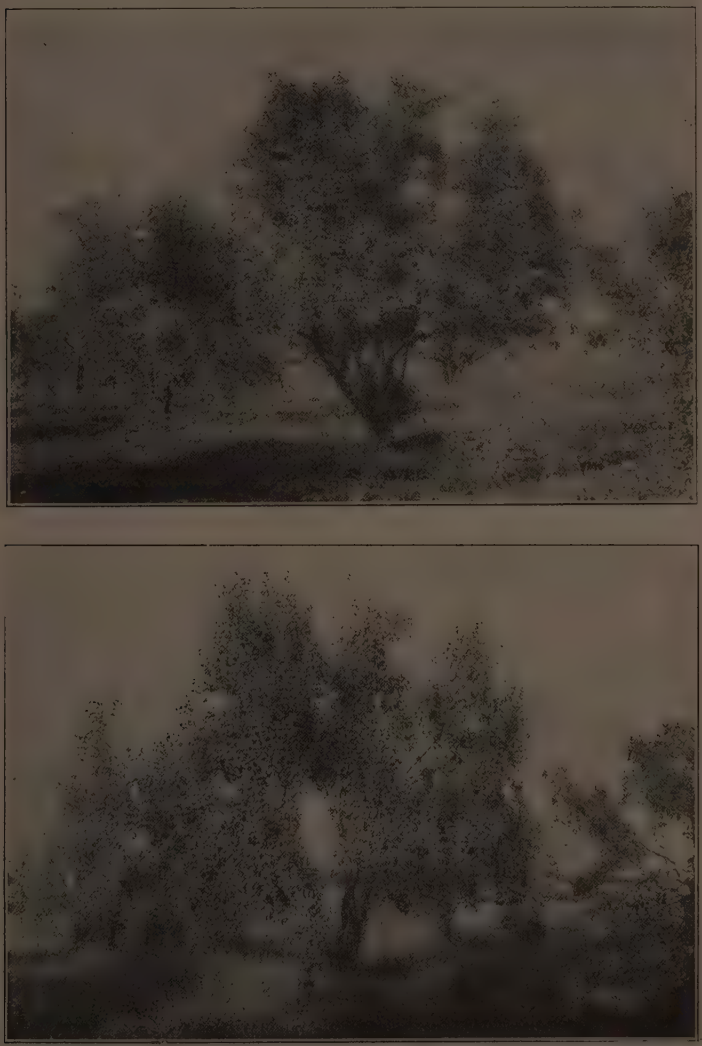
FIG. 15. The cut-back trees produced large fruit. Notice the Bordeaux spray still plainly visible at picking time upon both fruit and foliage.

The pruning had thinned the fruit and at the same time reduced the top to such a degree that an abundance of plant food was made available, the result being a great increase in the size of the fruit, and a vigorous growth of the top. (Figs. 16-19, inclusive.)





FIGS. 16, 17. The effect of blotch upon the tree. Figure 16 was photographed a short time after growth started in the spring. Figure 17 is the same tree as it appeared in the fall. Compare these illustrations with figures 18, 19.



FIGS. 18, 19. This tree appeared in early spring, before cutting back, almost exactly the same as that shown in figures 16, 17. These two trees received no spray during 1910 and 1911, but both received Bordeaux during 1912. The difference in the trees and crop is due to the cutting-back work.

The following tables, giving the yields of five average pruned and five average unpruned trees, indicate the value of the experiment from a commercial standpoint for the past season:

TABLE No. 12.—Commercial yield in bushels from five unpruned trees when graded into fancy, ones, twos, and culls.

MISSOURI PIPPIN.

TREE.	Bushels.				
	Fancy.	Ones.	Twos.	Culls.	Total.
A-1	.50	6.12	5.25	.75	12.62
A-16	.12	2.50	.75	.50	3.87
C-6	.25	2 25	2.00	.25	4.75
D-16	.50	1.75	2.00	.50	4.75
D-4	1.00	3.15	2.00	.25	6.40
Totals	1.37	15.77	12.00	2.25	32.39
Average	.27	3 15	2.40	.45	6.47
Per cent	4.24	48 73	37.09	6.94	.....

TABLE No. 3.—Commercial yield in bushels from five pruned trees when graded into fancy, ones, twos, and culls.

MISSOURI PIPPIN.

TREE.	Bushels.				
	Fancy.	Ones.	Twos.	Culls.	Total.
B-1	.75	3.00	1 25	.12	5.12
B-7	1.60	2.36	.84	.60	5 40
C-1	.75	3.12	.60	.12	4.59
E-3	84	4.50	1.00	.12	6 46
E-1	2 00	2.25	.36	.12	4 73
Totals	5.94	15.23	4 05	1.08	26 30
Average	1.18	3.04	81	.21	5.26
Per cent	22 43	57 79	15.39	3.99	.....

A marked increase in the yield of the high-priced grades is noticed in these data, the greatest difference being in the per cent of fancy and twos. The cut-back trees show a gain of 18.19 per cent in fancy fruit, 9.06 per cent in firsts, and a decrease of 21.70 per cent in seconds, and 2.95 per cent in culls. The unpruned trees show a gain in total yield of 1.21 bushels per tree, but the cash value of the better grades of fruit from the cut-back trees more than offsets this difference. The fruit from the medium and heavy cut trees graded higher than that from the trees pruned lightly, but the total yield was a little less from the severe pruning.

The effect of this work upon the individual tree has been uniformly good. In each case a good growth resulted, and by keeping this new wood covered with Bordeaux, almost no blotch cankers have formed.

The bearing wood has been brought lower, making spraying and picking easier, and new growth has been forced on the barren branches, which in due time will increase rather than lessen the total bearing surface. Many of the new shoots will need to be removed in order to prevent a dense top, but by judicious pruning a well-balanced, strong, open head will result.

Two Ben Davis trees were cut back rather severely at the same time the Missouri Pippin trees were being pruned, and the effect of the treatment upon the tree in each case was similar to that recorded above. These trees had set little fruit, however, and this part of the result was not obtained, although it would probably have been similar to the effect upon the Missouri Pippin.

From the results obtained in this work, it seems probable that an orchard containing many blotch cankers would be greatly benefited by this cutting-back process of pruning. It would be necessary to follow this pruning with careful spraying to prevent the young, tender shoots from becoming infested with blotch cankers. This rapid growth is more susceptible to injury than the ordinary shoots, and unless spraying was carefully and thoroughly done more harm than good might result. All wounds of two inches or more should be covered, as soon as dry, with some good paint.

Spraying Experiment.

The spraying work carried on during this season was arranged especially to compare the values of a ten days' and three weeks' spray as the first application in the control of blotch. The dates of the second application were also varied from four to five and seven weeks after the petals were down. Home-made concentrated lime-sulphur was applied to all rows alike at the time of the falling of the petals, and Bordeaux 3-4-50 was used in all later sprayings, making the sprays applied throughout the season entirely comparable.

The home-made lime-sulphur was prepared by boiling 40 pounds of lime and 80 pounds of sulphur in 50 gallons of water for 45 minutes. This concentrated solution was stored in bar-

rels and diluted to the regular spraying strength at the time of application. By the use of the Beaume hydrometer it was found that 2 gallons of this solution would be required to 50 gallons of water for summer spraying. The solution was thoroughly satisfactory in every way.

The same method was used in the preparation of the Bordeaux mixture as described for the season of 1911, and each application was made with the utmost care. A Cushman 1912-model gasoline power sprayer was used in applying the spray, and a pressure of 200 pounds was maintained.

Three-row blocks were used for all the tests, and the count trees were selected from the center row, thus making the results as indicative of the real value of the spray as possible.

SPRAY OUTLINE.

L-S, lime-sulphur; Bx, Bordeaux.

	Petal-fall.	Ten days.	Three weeks.	Five weeks.	Seven weeks.
BLOCK I.... ...Row A, Row B, Row C	L-S—2-50	.....	Bx—3-4-50	.....	Bx—3-4-50
BLOCK II.....Row D, Row E, Row F	L-S—2-50	Bx—3-4-50	.....	Bx—3-4-50	.....
BLOCK III.....Row G, Row H, Row I	L-S—2-50	Bx—3-4-50	Bx—3-4-50	Bx—3-4-50	.....
BLOCK IV.....Row J, Row K, Row L	L-S—2-50	Bx—3-4-50	.....	Bx—3-4-50	Bx—3-4-50

TABLE NO. 14.—Comparative values of different dates of application as indicated by an examination of each apple which set on each count tree.

BLOCK I.—Miss uri Pippin.

TREE.	Total fruit.	Blotch.	Per cent blotch.
B-15	1,331	38	2 8
B-10	3,463	62	1 8
B-2	2,551	80	3 1
B-5	3,227	83	2 6
Total	10,572	263	.....
Average	2,643	65	2 4

BLOCK II.—Missouri Pippin.

E-2	4,287	288	6 7
E-5	5,858	9 9	16 6
E-8	1,742	201	11 5
E-11	2,182	171	7 8
E 16	1,467	182	12.4
Total	15 536	1,821	.....
Average	3,107	364	11 7

BLOCK III.—Ben Davis.

TREE.	Total fruit.	Blotch.	Per cent blotch.
H-2	3,044	89	2.9
H-5	1,210	69	5.7
H-9	1,442	52	3.6
H-12	2,658	57	2.1
Total	8,354	267	.....
Average	2,088	66	3.1

BLOCK IV.—Ben Davis.

K-2	2,020	91	4.5
K-5	1,487	75	5.0
K-8	1,983	188	9.5
K-11	2,491	64	2.5
Total	7,981	418	.....
Average	1,995	104	5 2

The data in these tables indicate that the application made three weeks after the falling of the petals is the most important spray for the control of the blotch. In each block which received this application the fungus was better controlled than when the ten-day spray replaced it. Since two varieties were used, blocks I and II being Missouri Pippins, and blocks III and IV Ben Davis, the difference in susceptibility of these varieties should be kept in mind when comparing the spray applications made.

The outline was so arranged that each two blocks would be comparable. Blocks I and II, when compared, indicate relative values for the three weeks' and ten days' sprays. It might be suggested that the difference was due to the change in the date of the last application, but by comparing block I with block IV, and keeping in mind the susceptibility of the two varieties, this condition is eliminated. Blocks III and IV show the same relation between the three weeks' and ten days' applications as noted for blocks I and II. The comparative values of a five weeks' and seven weeks' application may be obtained from blocks II and IV, provided proper allowance is made for the use of two varieties.

General Summary and Recommendations.

The results obtained in the various tests included in this investigation prove that the apple-blotch fungus can be controlled. Not often will worse conditions confront the grower than were found in some of the orchards used in these experiments. In the most susceptible varieties, showing an enormous amount of cankers, the disease has been reduced to less than 5 per cent of injury by the application of Bordeaux mixture. In orchards composed of less susceptible varieties, less than 1 per cent of injury followed the Bordeaux treatment, and almost as good results the lime-sulphur spray. It has been found that the disease on the fruit can be controlled the first season by spray applications, and that by following the same treatment during successive seasons it can be almost entirely eradicated from the orchard. This process can be hastened and the injury materially lessened by removing the worst-cankered and useless limbs from the infested trees.

Bordeaux mixture frequently causes serious burning, and an investigation of the methods generally used in preparing this mixture has led the author to the conclusion that three factors are largely responsible for this injury: First, a stronger mixture than necessary to control the fungi is ordinarily used; second, unsatisfactory methods are frequently employed in mixing; third, a poor grade of lime, or air-slaked lime, is commonly used. Investigations both in the laboratory and in the orchard have shown that 3 pounds of copper sulphate and 4 pounds of well-slaked stone lime for each 50 gallons of water make a Bordeaux which, for all summer orchard work, is effective and less liable to injure tender fruit and foliage than that made according to the stronger formulæ. Laboratory experiments show that three pounds of stone lime is an ample amount to neutralize three pounds of copper sulphate, but when this mixture is applied to the tree it invariably gives more burning than when the extra pound of lime is added. This seems to be due to the fact that the extra lime found in the Bordeaux in an uncombined state will neutralize any copper sulphate liberated by chemical action from the salts contained in Bordeaux mixture after it has been applied to the tree.

Bordeaux which contains the greatest amounts of such undesirable salts ordinarily is made by one of the following processes: pouring the copper-sulphate solution and milk of lime together in concentrated form, after which the required amount of water is added; by placing the undissolved lime and copper sulphate in the tank and adding water; by pouring a strong solution of one of the ingredients into a dilute solution of the other; by using air-slaked or a poor grade of lime, or even by pouring a dilute solution of one into a dilute solution of the other of the two components. It is not to be understood from this that Bordeaux made by each of the above unsatisfactory methods would always cause serious burning, but rather that the mixture will contain chemical conbinations which, when the weather conditions are favorable for burning, will break down and liberate copper sulphate much more readily, and the consequent burning will be much more serious than when the correct method is used.

The Correct Method of Making Bordeaux. In order to make an effective Bordeaux, and one that is the least liable to cause burning, the copper sulphate and lime should be added each to one-half the total required water, and these two dilute solutions allowed to run together, in equal quantities, into a third tank. There is nothing new about this method, as it has been in use for years, but ordinarily the beginner tries to lessen the time and labor involved in this process, with the result that serious injury follows. The manner in which these two solutions are mixed may be varied according to convenience, just so the two are mixed in equal dilute quantities. Very frequently, when small amounts of Bordeaux are required, the two dilute solutions are poured together into the spraying tank by hand. When large quantities are to be made, however, two tanks, each large enough to hold a little more than one-half the volume of the spray tank, should be placed upon an elevated platform at such a height that they will drain into the top of the spray tank. The two dilute solutions are then made in these tanks and allowed to run together through equal-sized openings into the spraying tank.

If care is used in weighing and mixing all materials and the 3-4-50 formula is used, there is little need of the potassium ferrocyanide test, as no free copper sulphate will be found. These tests show only the presence of the free copper sulphate,

and do not detect the presence of chemical salts liable to break down and liberate copper sulphate after the mixture is added to the tree. For this reason, a 6-6-50 Bordeaux, or frequently one made with poor lime or air-slaked lime, would appear as harmless by any of the ordinary tests as Bordeaux made by the 3-4-50 formula, but the effect upon the tree, especially under unfavorable weather conditions, would soon indicate a difference.

Much care should be taken in slaking the lime used in Bordeaux mixture. It should not be entirely covered with water, but only enough water added to carry on the process without burning. After the slaking process is over, the lime should be thoroughly mixed with water until a milky fluid is obtained, when it is ready to add to the required amount of water to bring the total volume up to one-half the water named in the formula.

The copper-sulphate solution is best dissolved by placing a known weight of the material in a burlap sack and suspending it in the top of a barrel or tank of water. If 100 pounds are dissolved in 50 gallons of water, 1½ gallons of the stock solution will be required for making 50 gallons of Bordeaux by the 3-4-50 formula.

The 4-4-50 or 5-5-50 formulæ are not to be advised for summer spraying in this state, as serious burning is liable to follow their use.

Time of Applications.

The first spray for the control of the blotch should be applied three weeks after the falling of the petals. The reason for making the first application at this time, instead of a week earlier or a week later, is that the blotch spores are being disseminated in greatest numbers from the last of this third week until probably the end of the fifth week. A few spores are liberated from the cankers before the first of the third week, but the number is so small that little infection takes place. By the time or shortly before the general bursting of the canker pycnidia, the three weeks' spray is applied, and, being fresh, is in the best possible time to prevent widespread infection. If applied a week later many of the early scattered spores would have already gained entrance into the fruit and twigs, and no amount of spray would then affect them.

Should dashing rains occur to wash the spray mixture from the fruit and tree, another application should be made as soon as necessary to insure constant protection.

If the weather at the regular time for this application is wet and continues cloudy, lime-sulphur should be substituted for Bordeaux, but as soon as possible after the weather becomes settled the Bordeaux should be applied, as it is more effective. This is, of course, for varieties badly injured by the blotch; on unsusceptible varieties the lime-sulphur would probably provide ample protection.

The second regular application would vary somewhat with the weather conditions, but should be applied on susceptible varieties in from two to four weeks after the first. The same precautions in regard to the use of Bordeaux should be taken at this time. The fruit is still susceptible to spray-burn, though less so than in the earlier part of the season.

When the ten weeks' spray is applied for the second brood of the codling moth, Bordeaux mixture should be applied together with the poison, making the third spray for the apple blotch. Frequently the first two applications control almost perfectly without this third spraying, but in badly infested orchards, and especially during a wet season, late infection may occur if this application is omitted.

It can not be said too often that absolute thoroughness is the secret of success. Care must be exercised, however, in not overspraying. The purpose is not to spray a tree until it drips, but to stop the process when a maximum amount of material will be left on the tree. This means to stop applying spray shortly before the spray collects in large drops and starts to run or drip off the tree.

Spray Machinery.

Any efficient spray machinery may be used for the application of the blotch fungicide. A machine giving a constant pressure of 200 pounds has been found to give a better mist and allow the work to progress more rapidly than one giving a less pressure. The hand pump must be equipped with nozzles intended for use with low pressure, in order to insure a good mist. The Friend type of nozzle has proven generally satisfactory for use with a power outfit. and the Mistry and Vermorel

nozzles having a good mist with the low pressures obtained with a hand pump.

Whatever the machine used, the most thorough work can not be done without an extension rod of sufficient length to reach well into the tree, and a tower from which the tops of the trees can be reached.

All sprays should be applied as a mist, since the object of the work is to cover all fruit leaves and young wood with an even, continuous coating of the fungicide.

Spray Schedule.

First Application.—Apply Bordeaux, 3-4-50, as a mist three weeks after the falling of the petals. In case of wet weather substitute lime-sulphur for Bordeaux. Apply Bordeaux as soon as the weather will permit.

Second Application.—From two to four weeks after the first application apply Bordeaux, 3-4-50, again as a mist. Use lime-sulphur if the weather is wet. Apply Bordeaux as soon as the weather will permit.

Third Application.—Apply Bordeaux as in the previous applications, ten weeks after the petals fall.

By adding arsenate of lead at the rate of 2 pounds to 50 gallons of the fungicide, any of the above materials may be made to assist in the control of insects. Such a combination adheres to the fruit and foliage better than the fungicide alone. During an extremely hot, bright spell of weather the lime-sulphur-lead combination frequently causes burning, but during such weather it is advisable to use Bordeaux rather than lime-sulphur.